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Laboratory modeling of recent active deformations fault zones

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Introduction.

The analysis of the repeated geodetic supervision which have been carried out in fault zones of regions with a various level of seismic potential has revealed new class of recent deformations was revealed as parametrically induced tectonic deformations of aseismic zones. Appearance of super-intensive (up to 5-7 cm per year or $5\text{-}7 \cdot 10^{-5}$) movement of earth surface in fault zones of seismic and aseismic regions occurred under the influence of extremely small external influence of natural (distant earthquake preparation, insignificant sedimentation) or man-caused (small changes of routine of oil production) genesis.

Detailed investigation of correlation between deformation and seismic processes in fault zones of Kopetdag's and Kamchatka's seismically active regions was carry out and reviled that in a period of decreasing of seismic activity deformation processes in fault zones begin activate and inversely. Proposed aspect, that effect of more intensity of deformation processes in aseismic fault zones due to absence of a dissipation seismicity.

It is obvious, that local abnormal deformation processes are formed in a mode quasi-static loading, created global and regional fields of pressure. Fault zones play a determining role in formation of recent abnormal deformation and seismic activity as at these zones are present and actively move pore fluids and short-term changes deformation and strength parameters of rocks [1, 2, 3]. All this testifies to actuality of

laboratory researches of changes of physical properties of samples of rocks at constant uniaxial loading

Ratio of local and general deformations of samples of rocks by long constant compression.

For revealing distinctions in character of deformation of not broken files and zones of tectonic faults tests of two kinds of samples were carried out [4]. The first are integral samples with initial cracking, the second – the weakened samples, i.e. samples which have been preliminary subjected to compression and in them the system of cracks has already been generated, at loadings close to destroying.

For creation of loading during long tests installations of modeling of geological processes have been used on the basis of modernized hydraulic testing machine Ï-250. They have been equipped with a hemisphere allowing the top plate press to be inclined, additional electro-contact manometers, the remote board of automatic registration of the control and maintenance of pressure. Realization of modernization has allowed supporting loading with accuracy of 5 % from the set level.

Experiments were carried out on samples of the cubic form with an edge 10 cm, made of monolithic carbonate rocks. For comparison of the general and local deformations in addition registered local deformations by resistive-strain sensors, pasted as several rosette-type strain gages on one of lateral sides of samples.

In each of rosette-type strain gages 0, 45 and 90 degrees, or 0, 120 and 240 degrees to an axis of the appendix of loading contained on three resistive-strain sensors, focused under corners 0. Each rosette-type strain gage allowed to supervise deformation of a local site by the area approximately 2,5÷4 cm^2. Frequency of interrogation of resistive-strain sensors made 5÷6 times per each day.

Such network of strain gauges simulating local geodetic networks of geodynamic test areas, allowed to register changes in time of main deformationsε_{max}andε_{min}, and also of some others invariant tensor of deformations. In particular, it was calculated warping$I = \varepsilon_{max} + \varepsilon_{min}$, reflecting change of the area of a surface of local sites, and also parameter $\mu g = \varepsilon_{min} / \varepsilon_{min}$ (analogue of Poisson's ratio), reflecting process cracking in a sample. Accuracy of definition of local deformationsε_i was not less then $5 \cdot 10^{-5}$, values$I$ – $7 \cdot 10^{-5}$, values φ - 1-2 degrees.

One of experiments on a sample dense fine-grained limestone proceeded five months during which the size quasi-static compression was supported at a level 0,7-0,8 from a ultimate breaking load (70ÌÏà). To repeated influence of loading was, subject already weakened, but the sample, which has not lost to residual durability. The value quasi-static loading thus was supported at a level near 10ÌÏà during six months.

For finding-out of influence of a level of pressure on character of process of deformation the data of tests of an integral sample with a level of loading about 0,3 ÷0,4 of destroying load (40÷50ÌÏà). Under quasi-static loadings the sample remained during almost ten months (more than 6800 hours). The time dependence of the general longitudinal deformation of samples during long tests looks like monotonously growing line from time to time complicated with separate abnormal variations.

The revealed variations can be divided into three groups conditionally: à) bathtub changes, á) sharp step changes, â) intervals of time with the increased values of speed of deformation.

Special interest for comparison of the general and local deformations is represented with changes of the deformation parameters designed for local sites of a sample, during course of the registered anomaly of the longitudinal deformation of the sample.

Time dependenceε_{max} as a whole corresponding for behaviorε_{w}, but the variation proceeds on a background of monotonous growth$g\varepsilon_{max}$. Behaviorε_{min} has distinguished fromε_{w} character and proceeds on different sites differently, down to anti phase changes.

Mosaic character of behavior is observed and in existential distribution of longitudinal and cross-section deformation of local sites. Such character, probably, is caused various strengthening properties of separate areas of a sample. So, in the field of the ending of visually observable macro crack, reduction longitudinal deformations (unloading) were marked and in the removed areas there was its growth.

In a zone of the ending of a macro crack the intensive local stretching accompanied with increase of the area of a surface of the given local site (growth$I$) was observed. It occurs due to formation fissuring hollowness (dilatation). As confirmation of it the increase in parameter μ describing a degree fissuring of a sample (a degree of heterogeneity of deformation) serves.

This dilatation process has the character located in space as on the next sites behavior$I$ and μ has essentially other character. Also various character of behavior is marked on various sites of a sample and for a corner of turn φ the main axes of deformation.

Thus, the revealed abnormal changes of deformation parameters of a sample specify complex and discrete character of deformation of separate areas of a sample with vivid evidence at the certain stages dilatation the nature of preparation of destruction.

Absence of changes of external influence on a sample and presence of abnormal changes of deformation parameters of a sample allow drawing a conclusion that they are caused by changes of internal parameters of medium, and these deformations, in this case are parametrical. Summarizing stated above, it is possible to note the following.

The time dependence of the general longitudinal deformation of samples during long tests looked like practically a straight line, monotonously growing line from time to time complicated with separate anomalies, the caused changes of internal parameters of a sample, that is parametrical deformations.

The value of the general (integrated) deformation of samples is essentially less (about 1 to 10) than size of local deformations. It is more than amplitude of changes of local deformation parameters in zones of concentration of pressure, rather than in not broken areas of samples. The quantity of abnormal changes of deformation of the weakened sample is more, than an integral sample, and they have the big amplitude and duration. More rare character of occurrence of abnormal changes of deformations is marked at small loadings, in comparison with experiments at the loadings close to destroying samples.

The revealed abnormal changes of integrated and local deformation parameters of a sample correspond to the dilatation nature of preparation of destruction.

0.1 Ratio of deformation parameters and activity of acoustic emission of samples of rocks.

For such reception of the information experiments with simultaneous registration of the general and local deformations, and also acoustic emission have been carried out.

During tests of samples registered quantity of signals in unit of time, or activity AE in a range of frequencies 100 kHz - 1ÌHz [5]. The interval of accumulation of pulses made 20 seconds. As receivers of signals served piezoelectric gauges with own frequency 500 kHz. Signals amplified the broadband amplifier and moved on an input of the discriminator. On an output of the discriminator there was normalized on amplitude and duration a signal if the following requirements were simultaneously carried out: à) the size of an entrance signal exceeds a preset threshold level, á) the quantity exceeding of level for 50ìêñ was not less than 5. Last condition has allowed cut off acoustic signals with frequency less 100êÃö. The quantity of pulses on an output of the discriminator was displayed by the digital counter, and also registered by recorders.

As a result of these researches the following conclusions are received.

During long tests of an integral sample the periods of activity of acoustic emission (AE) by duration till several o'clock and intensity up to several tens pulses a second are marked. Obviously, they are caused by destruction of a local zone of a sample with presence of the main push, and then reduction in activity in time (analogue aftershock activity after the basic earthquake). The periods of activity ÀÝ during carrying out of experiment on the weakened sample were shorter – some minutes – and had the form of group of pulses, intensity ÀE achieved first hundreds pulses in one hour.

The significant changes of local deformation parameters anticipating activization ÀE are marked. Sources ÀE, probably, were near to sites with the maximal changes of local deformations. Development micro cracking, accompanied with radiation of acoustic energy, occurred in a direction of the next sites. Significant changes of local deformations after realization of activization ÀÝ can be an attribute of unloading of local pressure in this area.

Comparison of activity ÀE and changes of the general longitudinal deformation of a sample results in a conclusion about their return interrelation: intensive changes of deformation are not accompanied by intensive allocation ÀE and on the contrary, intensive allocation of energy ÀE is not accompanied by changes of deformation parameters in conditions is long working quasi-static loadings.

This result fully complies revealed in active seismic regions [3] with interrelation between deformation and seismic processes which can be presented as two forms of realization of the saved up potential energy: volumetric (deformation) and shear (seismicity).

Conclusion

Thus, the results of laboratory researches of samples of rocks submitted in the given work completely confirm parametrical character of abnormal changes of deformations and interrelation of seismic and deformation forms of development potential energy in zones of tectonic faults.

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